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Fisher et al.

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(54) **POD COVER SYSTEM FOR A VERTICAL TAKE-OFF AND LANDING (VTOL) UNMANNED AERIAL VEHICLE (UAV)**

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(51) **Int. Cl.**

B64F 1/00 (2006.01)
B64C 29/02 (2006.01)
B64C 39/02 (2006.01)

(52) **U.S. Cl.**

CPC .... ***B64F 1/005*** (2013.01); ***B64C 29/02*** (2013.01); ***B64C 39/024*** (2013.01); (Continued)

(58) **Field of Classification Search**

CPC .... B64C 2201/021; B64C 2201/088; B64C 2201/141; B64C 2201/201; B64C 29/02; (Continued)

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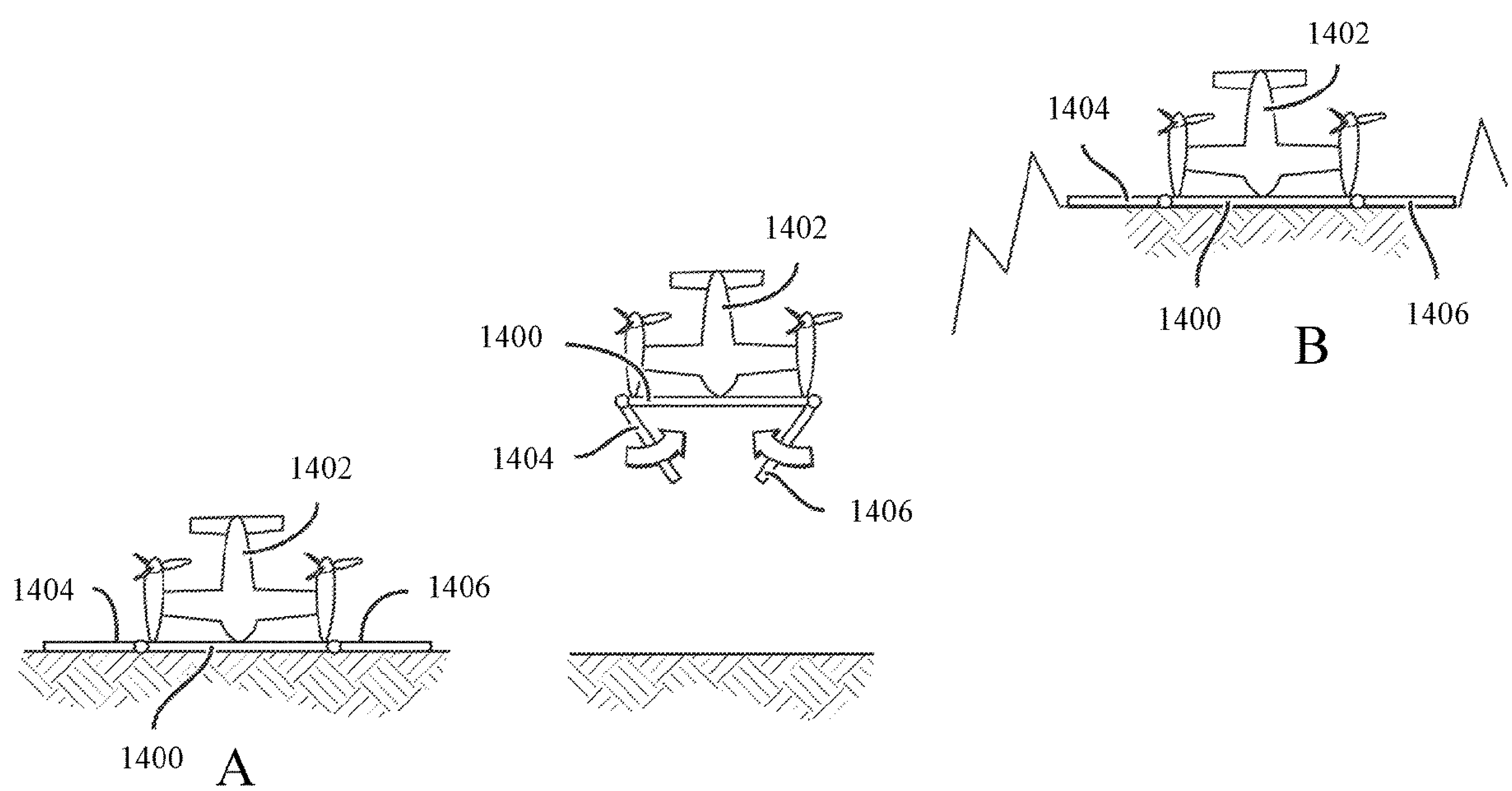
(57) **ABSTRACT**

An unmanned aerial vehicle (UAV) storage and launch system includes a UAV pod having an open position and a closed position, the closed position establishing an interior that is weather resistant to an environment external to the UAV pod and a vertical takeoff and landing (VTOL) UAV enclosed in the UAV pod so that the UAV pod in the closed position provides a weather resistant interior for the VTOL UAV.

21 Claims, 8 Drawing Sheets



(52) **U.S. Cl.**
CPC .. *B64C 2201/021* (2013.01); *B64C 2201/088* (2013.01); *B64C 2201/141* (2013.01); *B64C 2201/201* (2013.01)

(58) **Field of Classification Search**
CPC B64C 39/024; B64F 1/005; B64F 1/36; B64F 1/02; B64F 1/04; B64F 1/10; B64F 1/00
See application file for complete search history.

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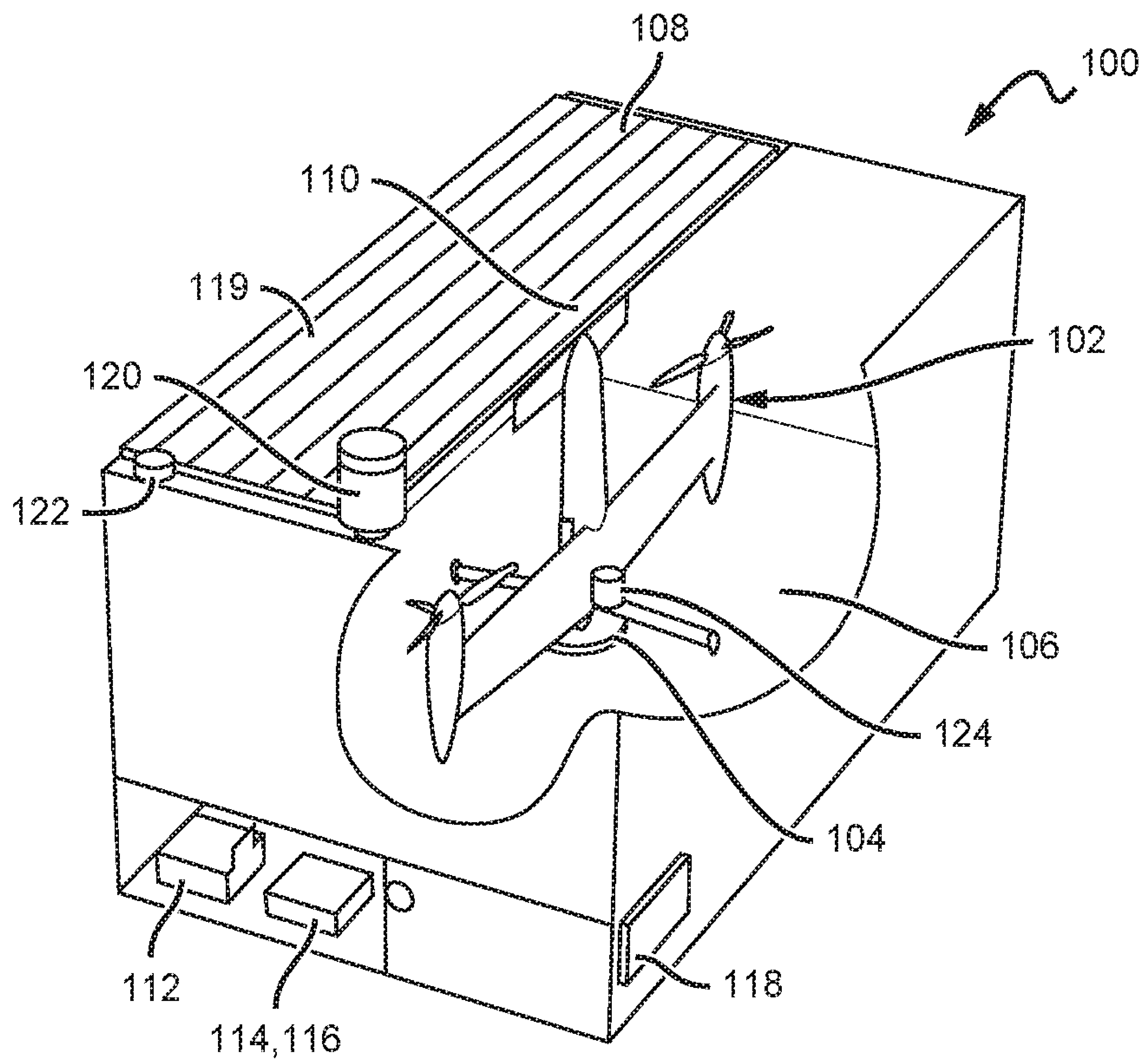
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FIG. 1

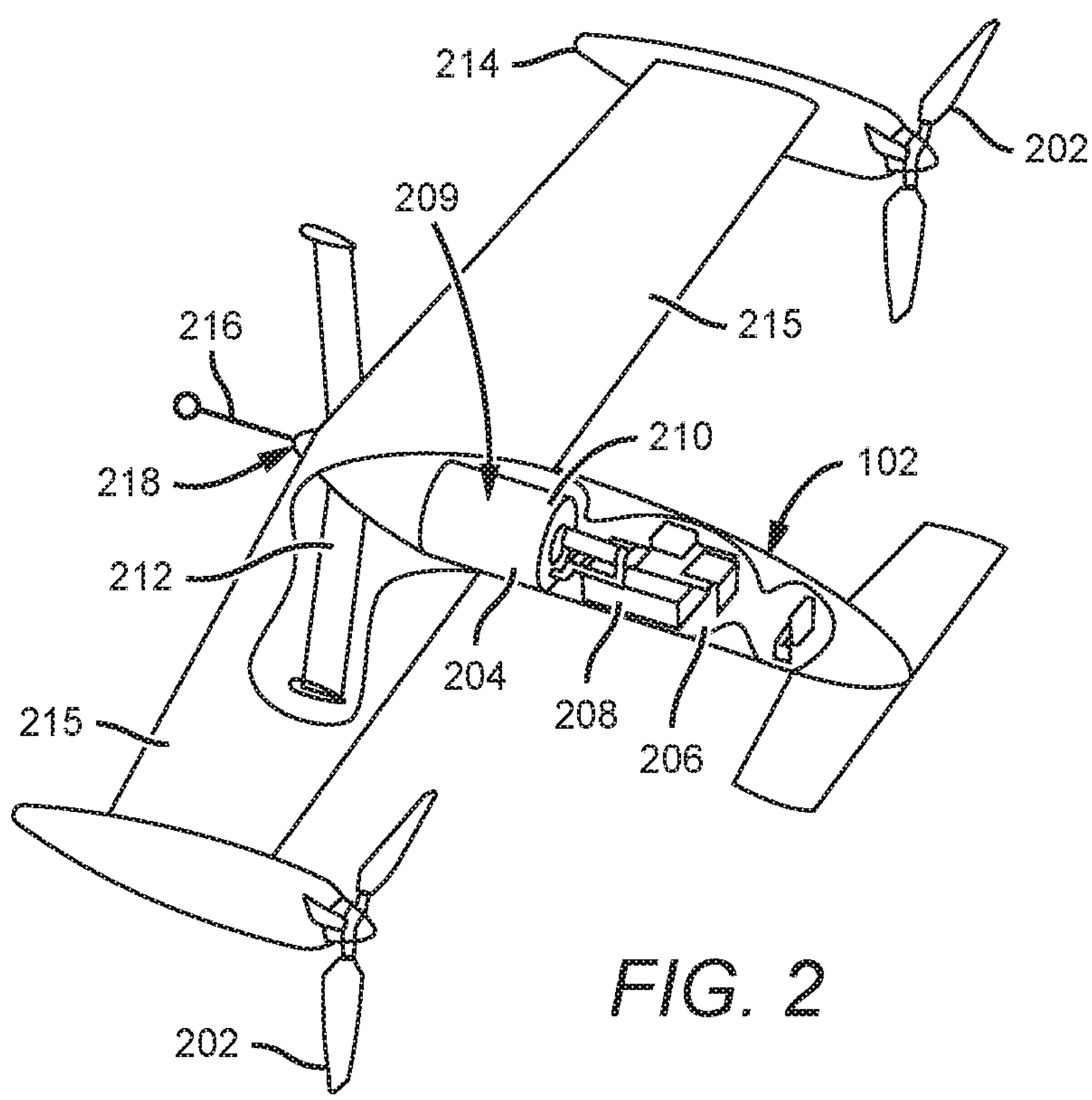
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FIG. 2

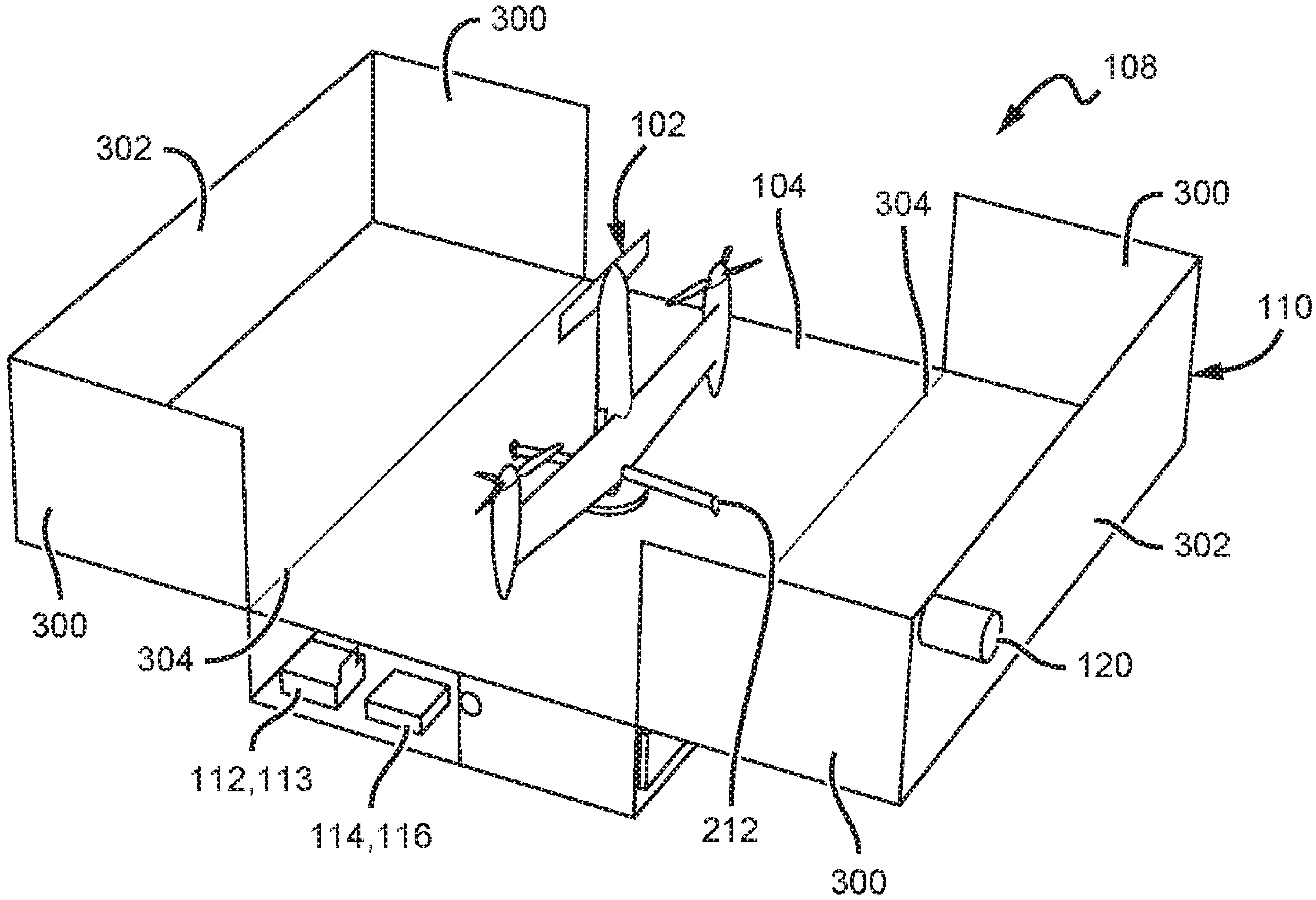
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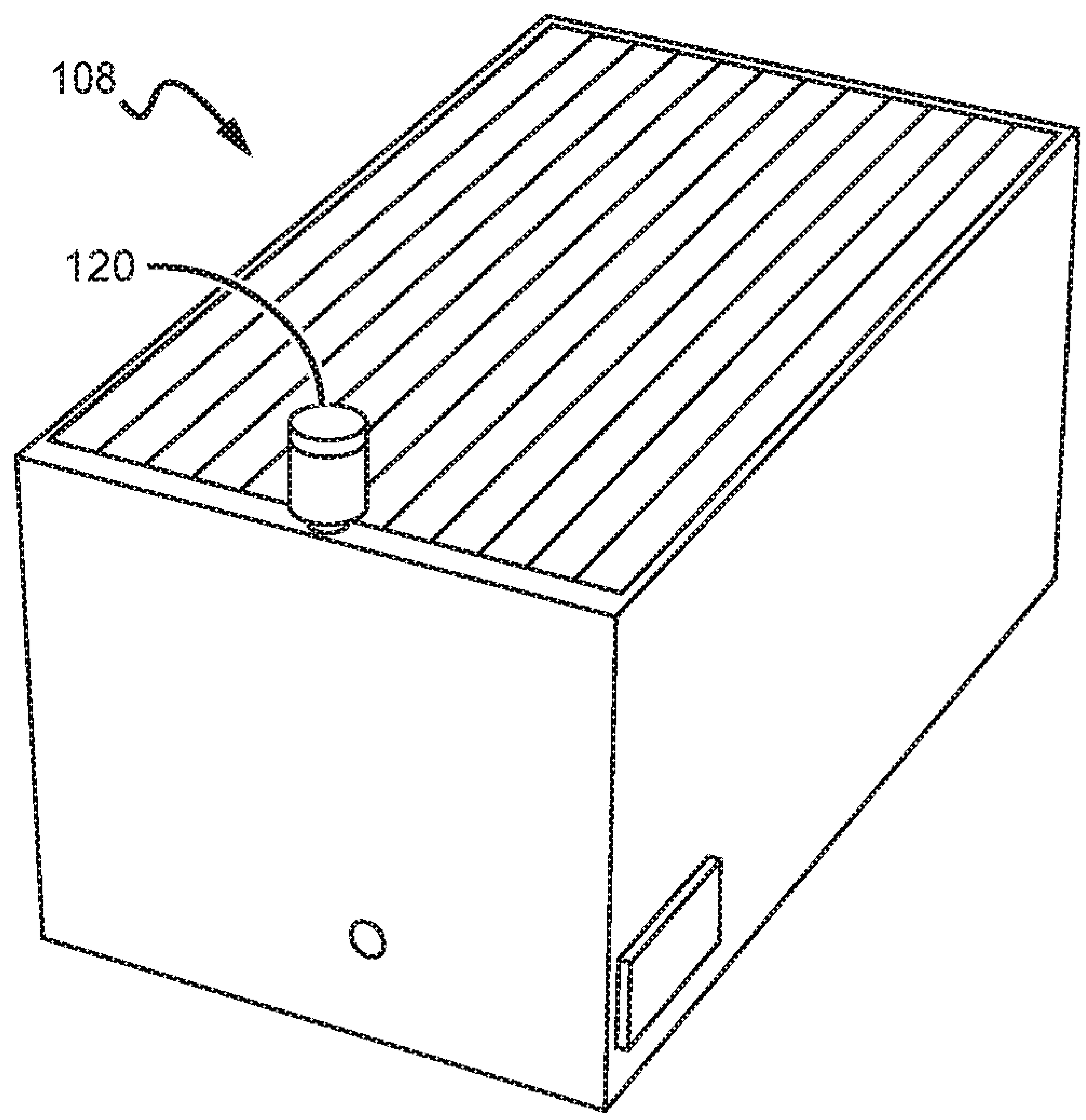
FIG. 3A

FIG. 3B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120

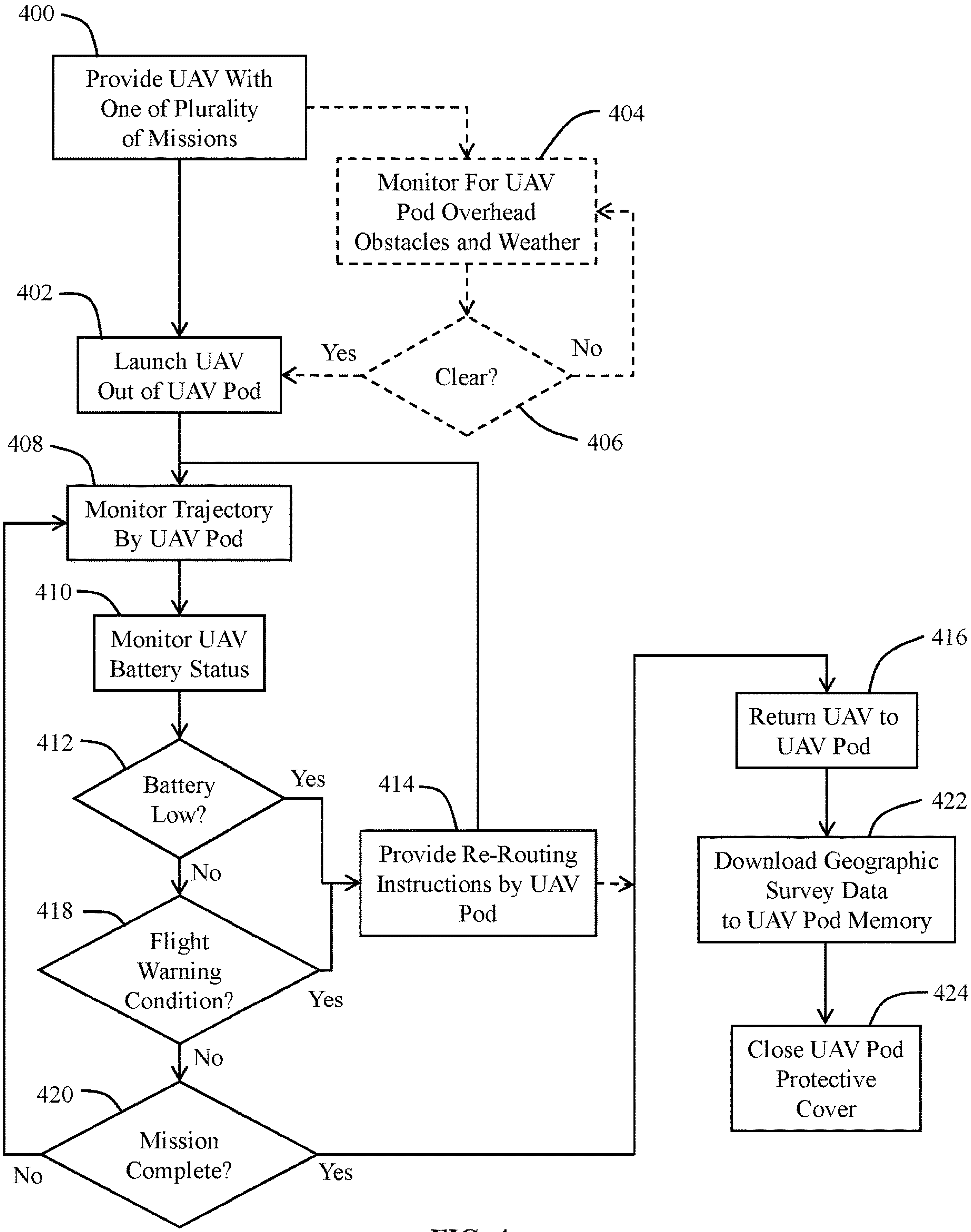
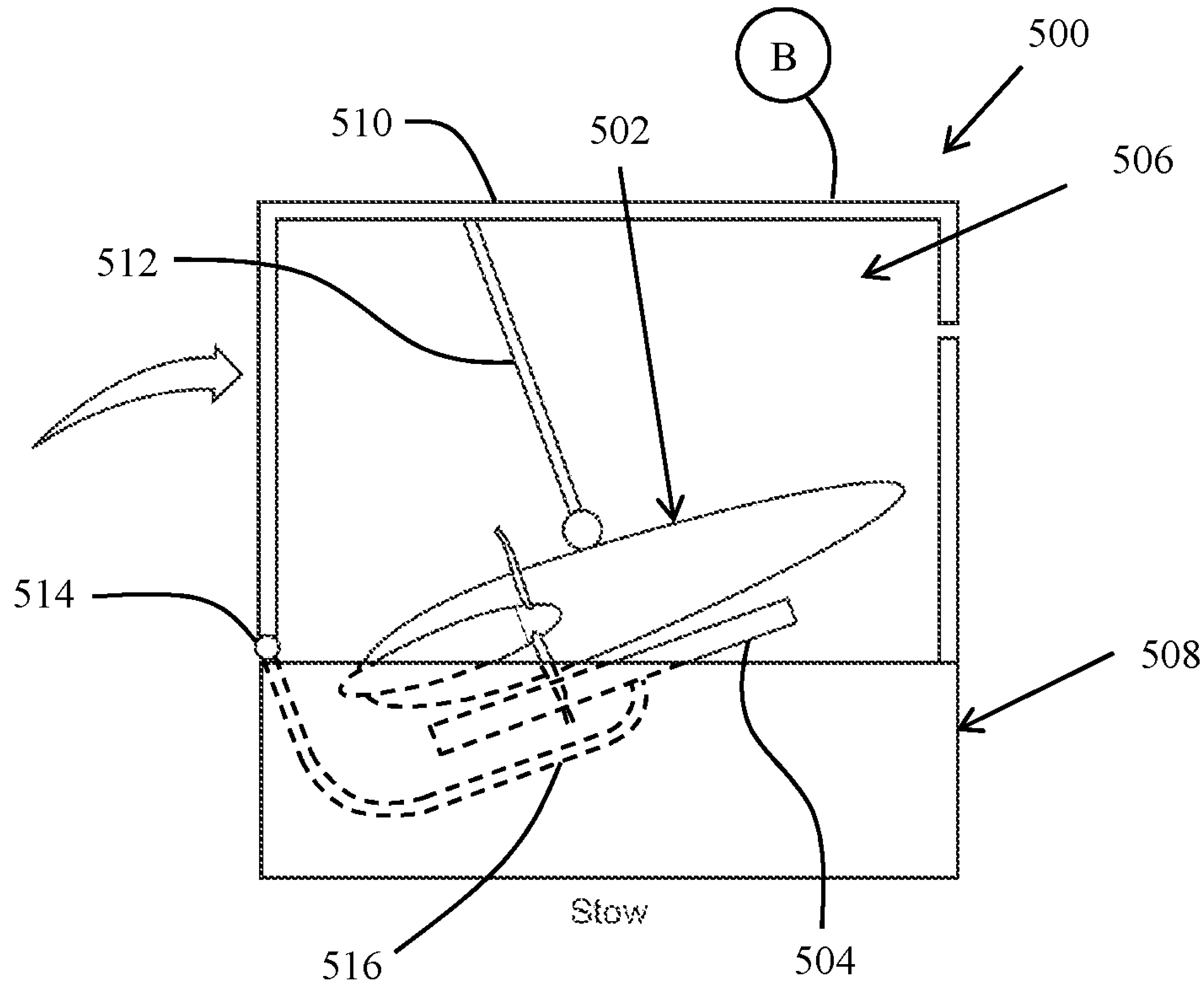

400
Provide UAV With One of Plurality of Missions
404
Monitor For UAV Pod Overhead Obstacles and Weather
402
Launch UAV Out of UAV Pod
Yes
Clear?
No
406
408
Monitor Trajectory By UAV Pod
410
Monitor UAV Battery Status
412
Battery Low?
Yes
No
414
Provide Re-Routing Instructions by UAV Pod
418
Flight Warning Condition?
Yes
No
420
Mission Complete?
No
Yes
416
Return UAV to UAV Pod
422
Download Geographic Survey Data to UAV Pod Memory
424
Close UAV Pod Protective Cover

FIG. 4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Stow
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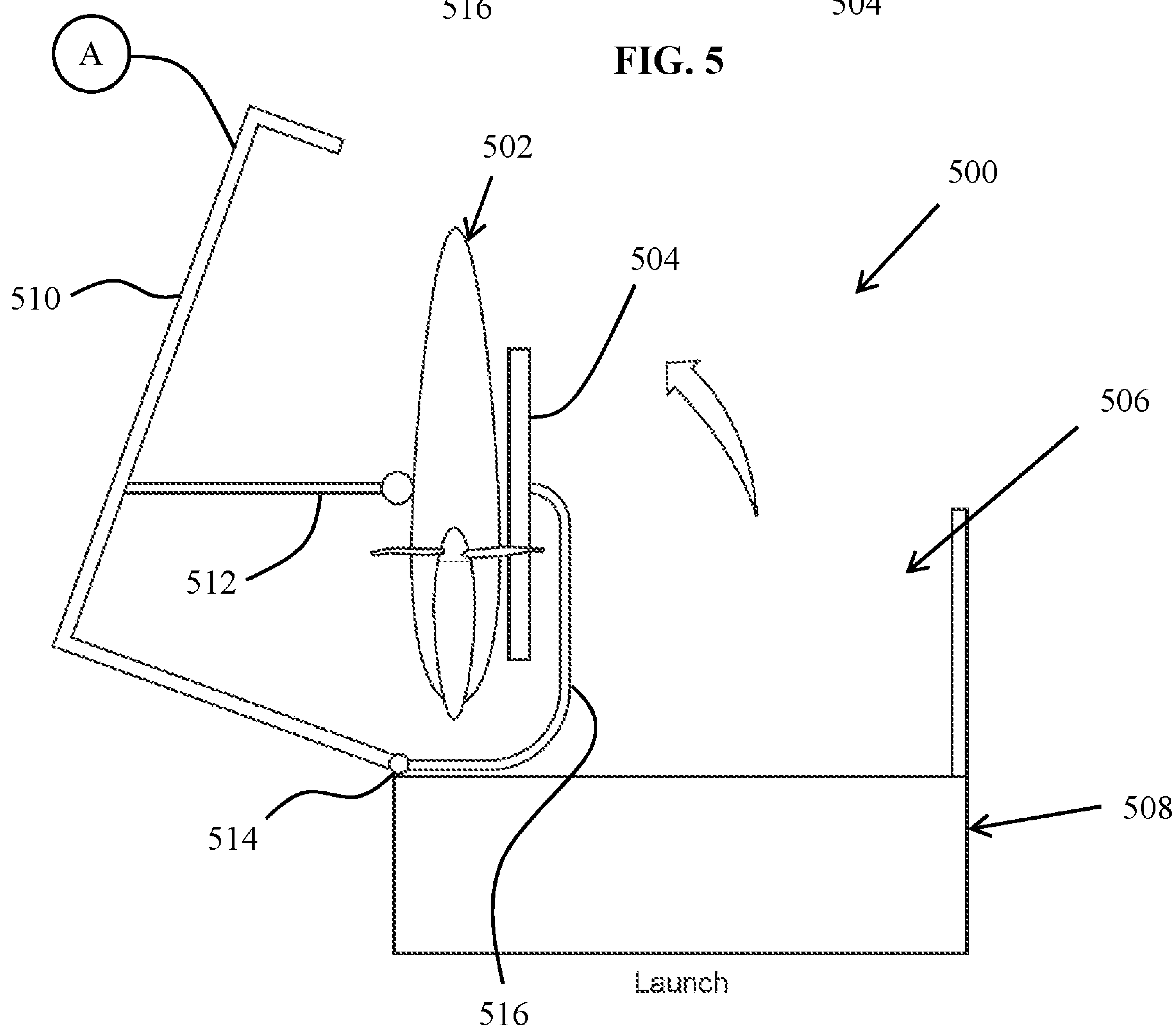
504

FIG. 5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514
508
Launch
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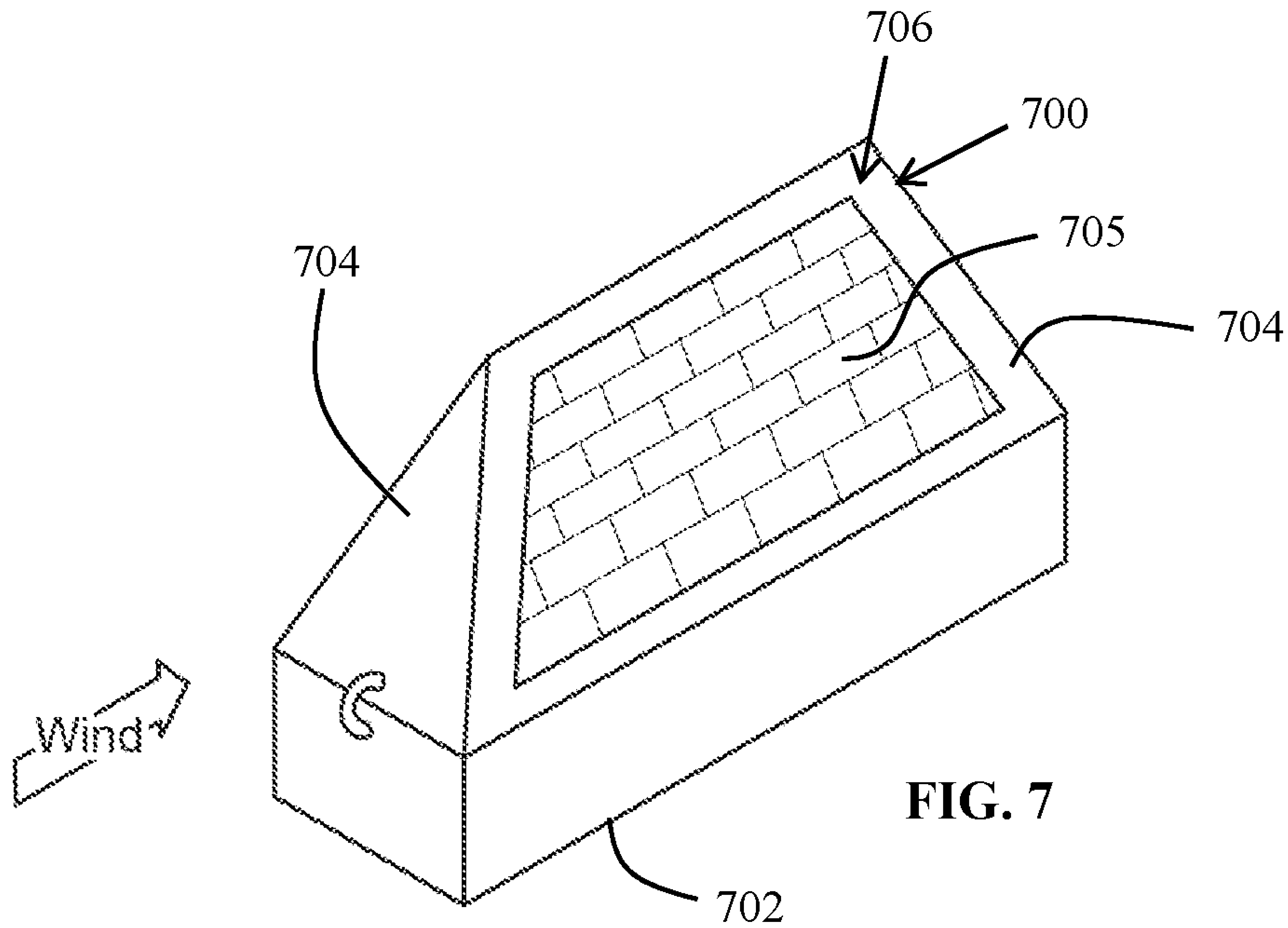
FIG. 6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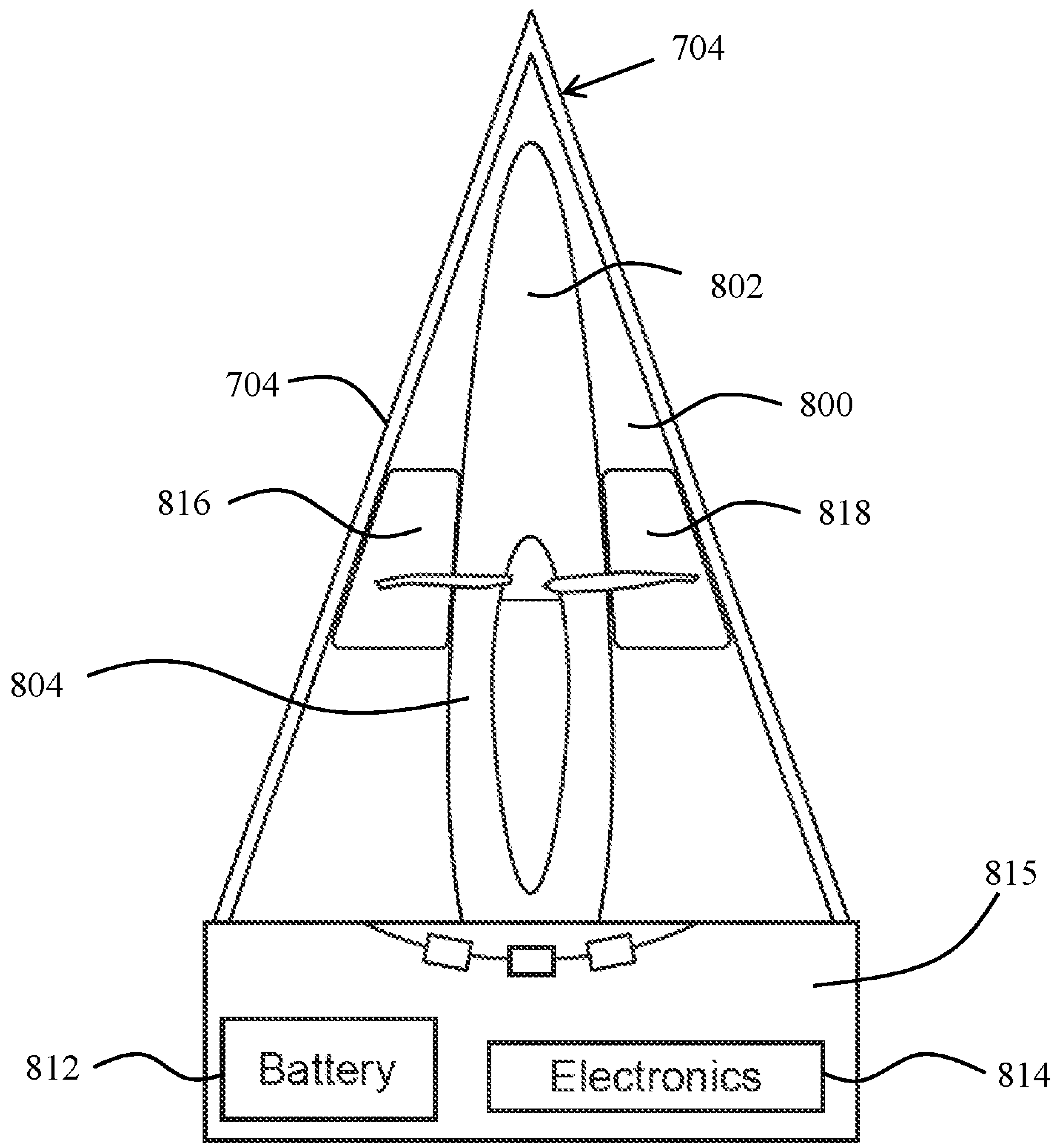
700
705
704
704
Wind
702

FIG. 7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802
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800
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818
804
815
812
Battery
Electronics
814

FIG. 8

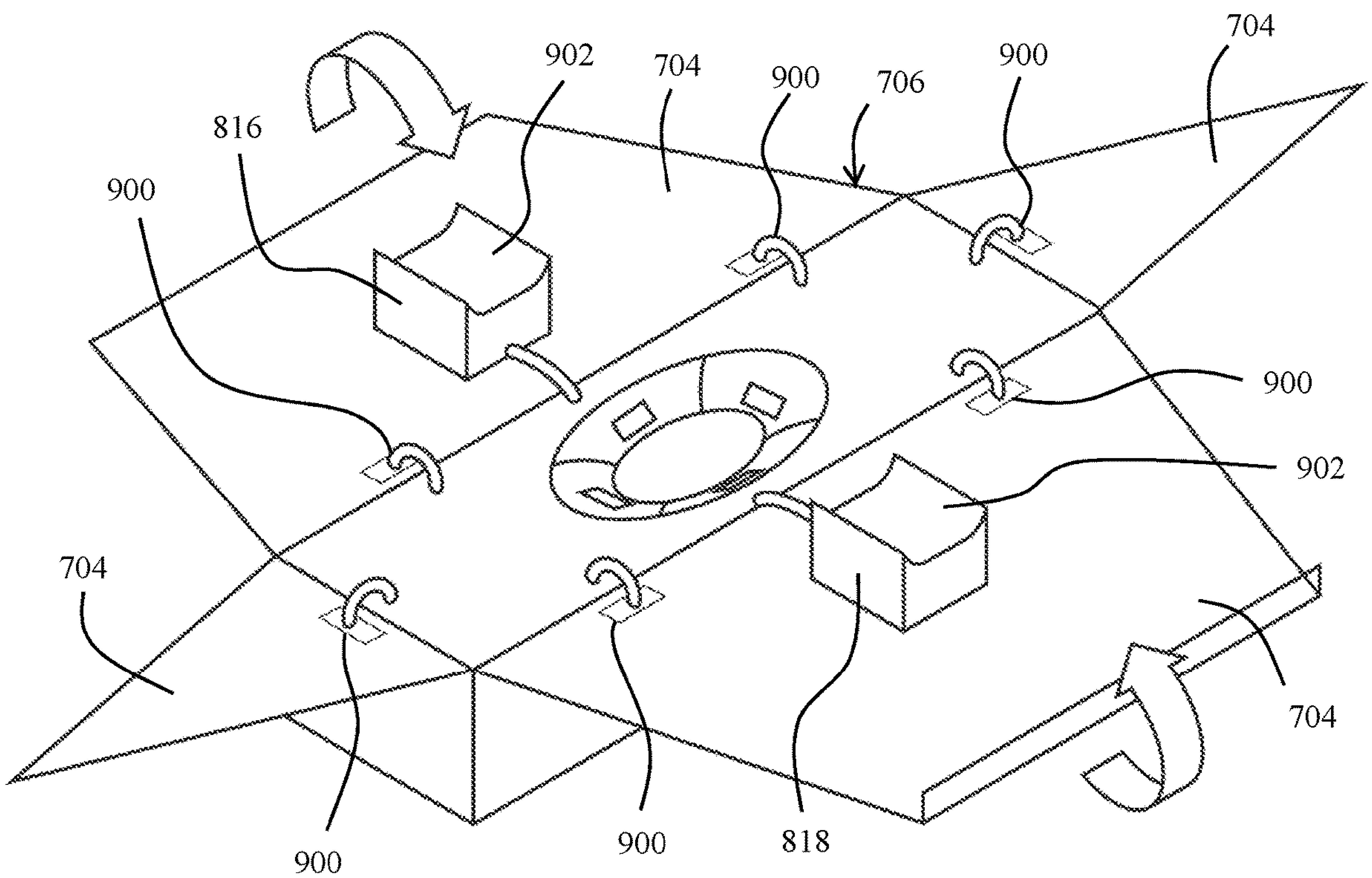


FIG. 9

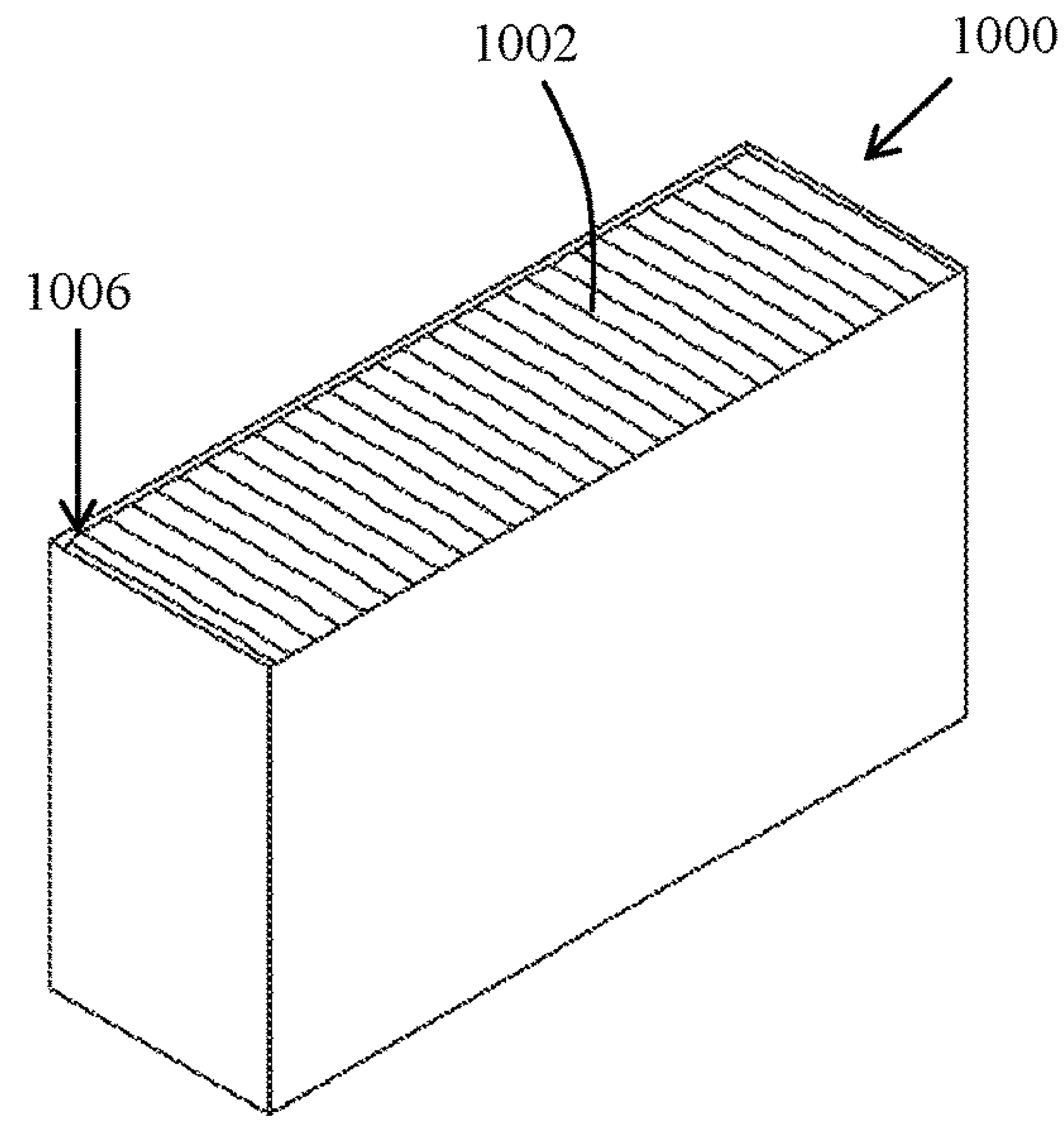


FIG. 10

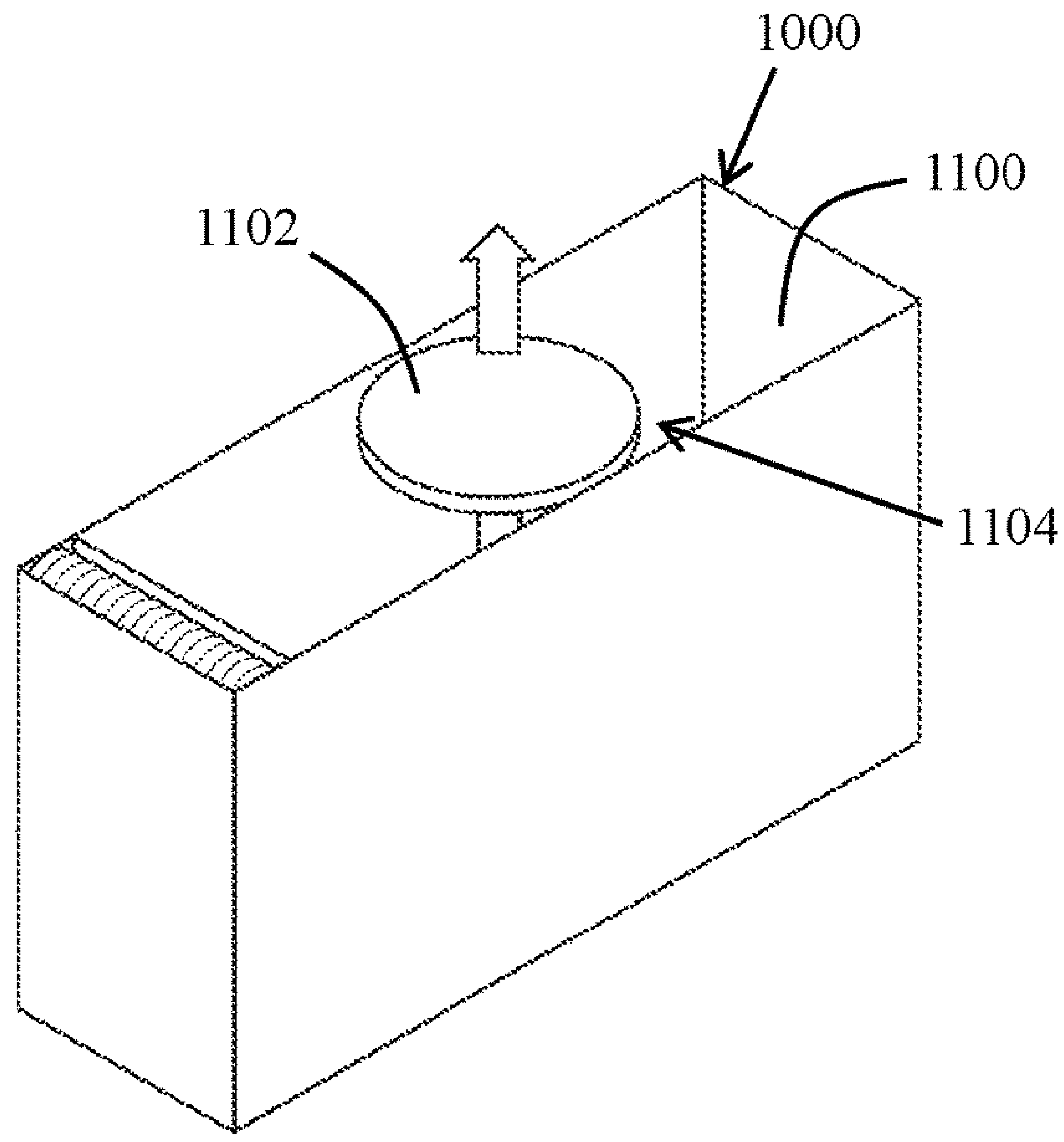


FIG. 11

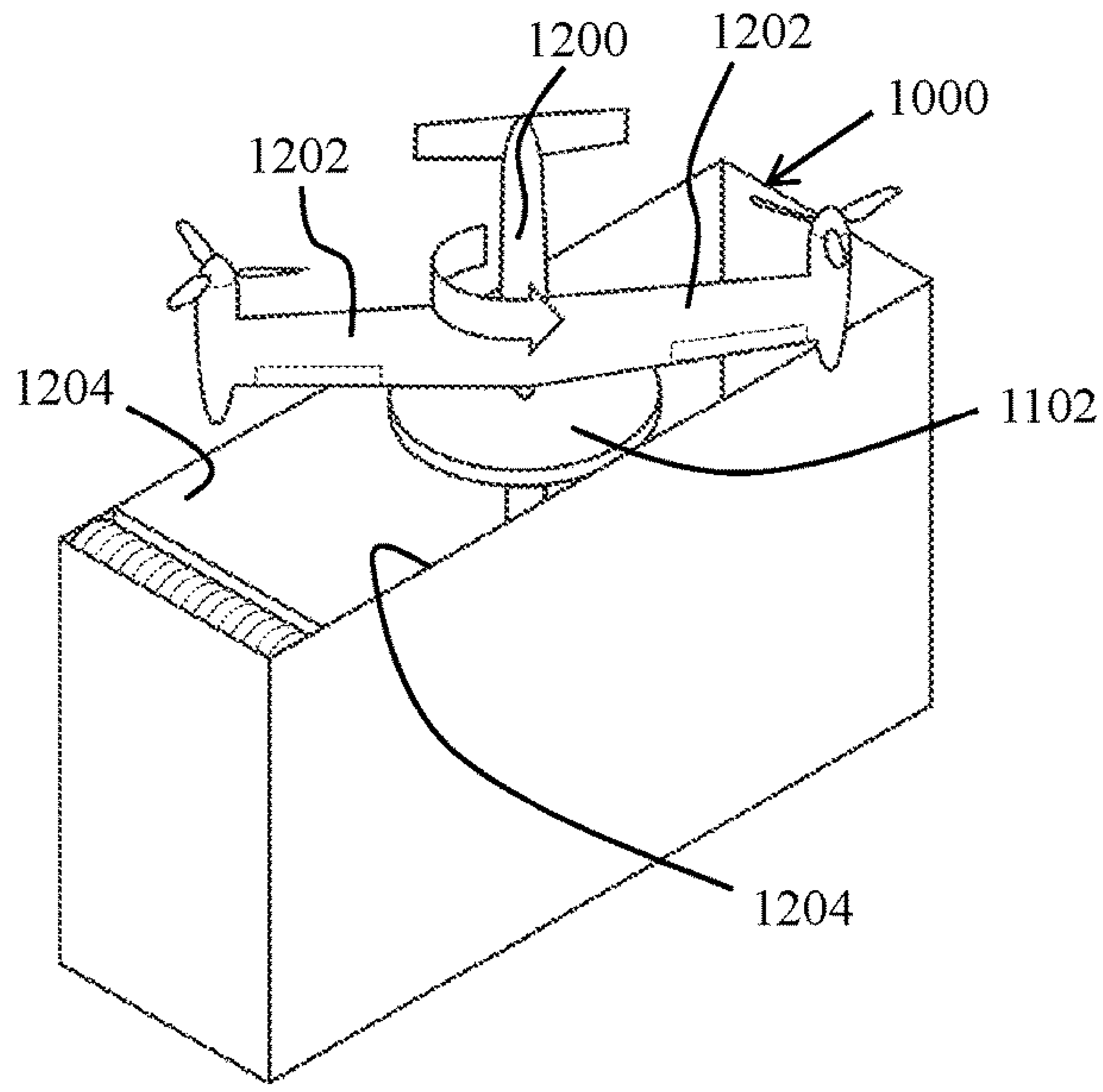


FIG. 12

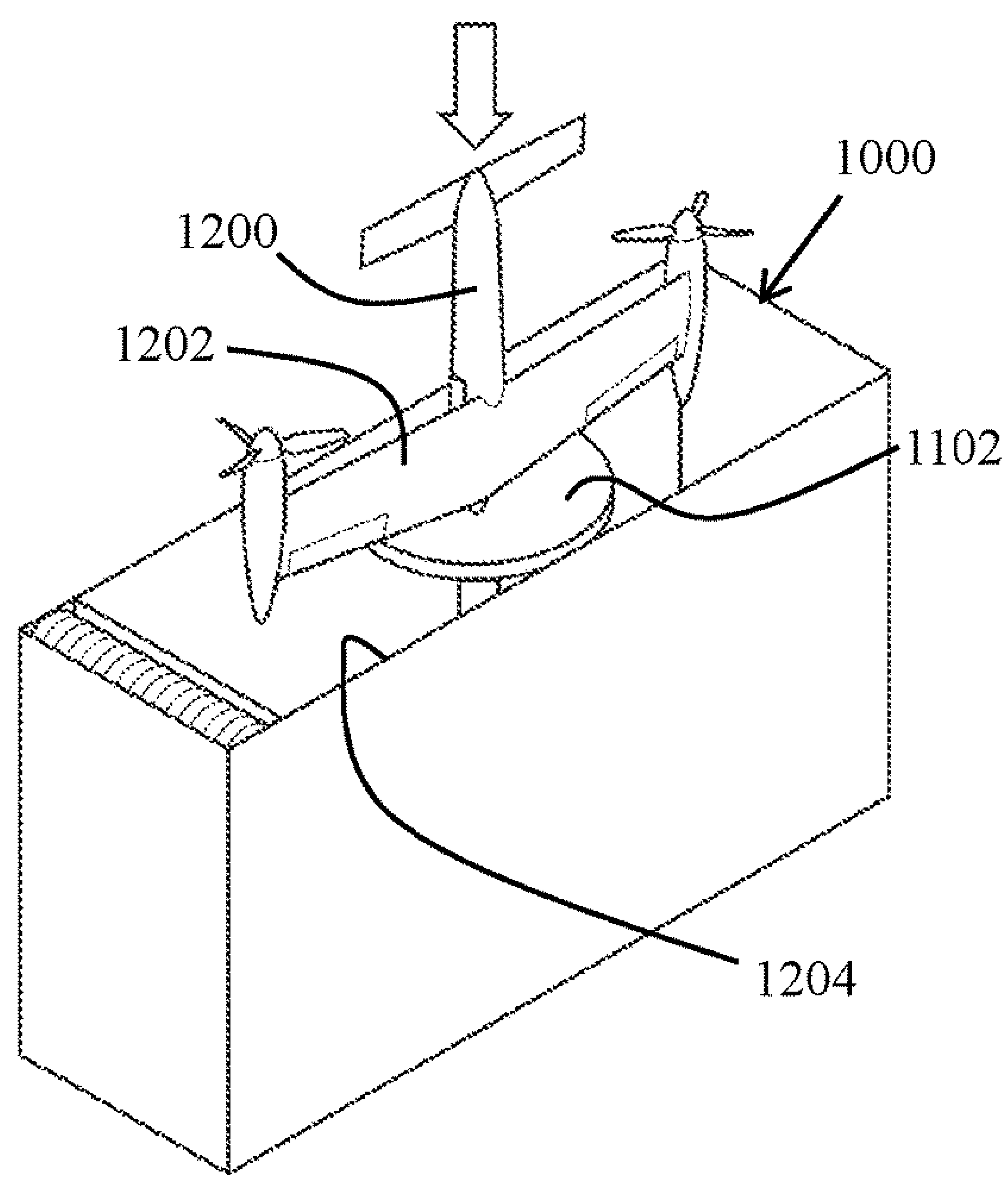
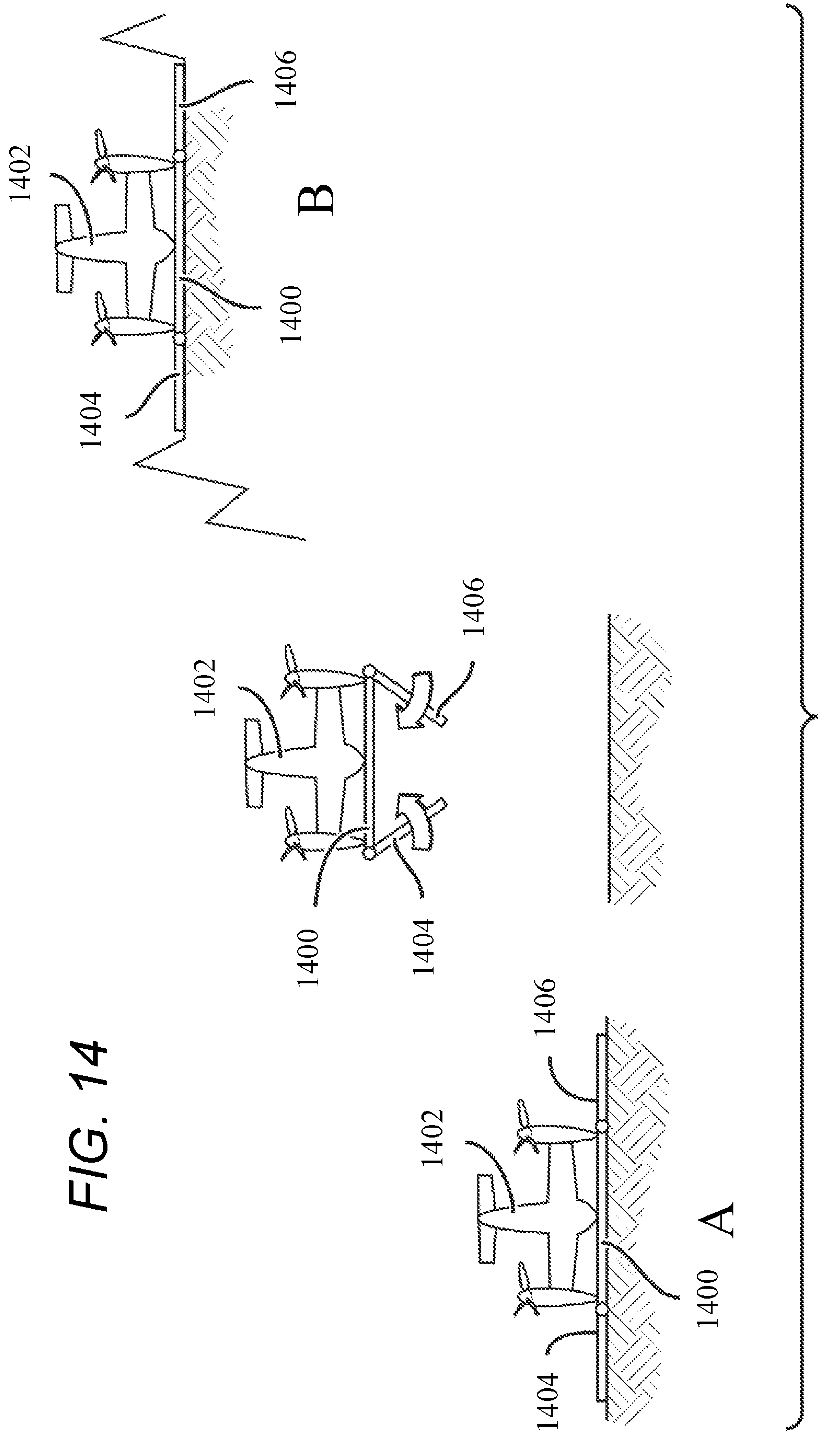


FIG. 13



1402
1406
1400
1404
B
1402
1406
1400
1404
1402
1406
1400
1404
A

FIG. 14

POD COVER SYSTEM FOR A VERTICAL TAKE-OFF AND LANDING (VTOL) UNMANNED AERIAL VEHICLE (UAV)

CROSS-REFERENCE TO RELATED APPLICATIONS

This application claims priority to and the benefit of U.S. Provisional Patent Application No. 62/115,074, filed Feb. 11, 2015, the contents of which are hereby incorporated by reference herein for all purposes.

BACKGROUND

Technical Field

The field of the invention relates to unmanned aerial vehicle (UAV) systems, and more particularly to systems for operating a UAV autonomously.

Description of the Related Art

Aerial geographic survey work for the agricultural and oil industries incur the logistics and costs of personnel to operate and maintain the air vehicle as well as collect and process the associated data. These costs are typically compounded by need for a substantial amount of this work to be performed at, or relatively near to, the location of the survey, which typically is well removed from any population centers. As a result, it is advantageous to increase automation, reliability (reduce complexity), range, and capability of an air vehicle and support system for performing such data retrieval and processing tasks.

SUMMARY

An unmanned aerial vehicle (UAV) storage and launch system includes a UAV pod having an open position and a closed position, the closed position establishing an interior that is weather resistant to an environment external to the UAV pod and a vertical takeoff and landing (VTOL) UAV enclosed in the UAV pod so that the UAV pod in the closed position provides a weather resistant interior for the VTOL UAV. The system may also include a two-part hinged cover that rotates away from the VTOL UAV when transitioning from the closed position to the open position, and may include solar panels on at least one exterior surface. The solar panels may charge at least one of a UAV pod battery and a VTOL UAV battery. In embodiments, the two-part hinged cover may be positioned to maximize the collection of solar energy by the solar panels and the two-part hinged cover may be positioned closed after the VTOL UAV is launched and returned to the open position before the VTOL UAV lands. In one embodiment, the UAV pod may include four lateral faces that rotate away from the VTOL UAV when moving from the closed position to the open position. The four lateral faces may be angled for low wind resistance in the closed position, and at least one of the four lateral faces may include a solar panel. The UAV pod may also include a pair of UAV support pads, each of the UAV support pads extending from a respective and opposing lateral face, wherein the pair of UAV support pads hold the VTOL UAV in position inside the UAV pod while in the closed position. The UAV pod may be waterproof in the closed position. In embodiments, the UAV pod also includes a top cover, and the top cover may laterally translate across a top opening of the UAV pod when transitioning from the closed position to the open position. The UAV pod may also include a proximity sensor, wherein the proximity sensor detects the presence of any object positioned over the UAV pod. The UAV pod may also include one or more UAV support pads, wherein the one or more UAV support pads hold the VTOL UAV in position inside the UAV pod while in the closed position. In such embodiments, the one or more UAV support pads may have a UAV-facing surface that have a complementary shape to an exterior of the VTOL UAV, so that the UAV-facing surface of the one or more UAV support pads resists lateral movements of the VTOL UAV inside the UAV pod. In one embodiment, the one or more UAV support pads extend from one or more opposing lateral faces of the UAV pod. The system may also include a UAV pod processor and a UAV pod transceiver in communication with the UAV pod processor. In such embodiments, the UAV pod processor may be configured to launch the UAV autonomously and without concurrent human intervention. The UAV pod processor may also be configured to receive geographic survey data and save the geographic survey data in a UAV pod memory in communication with the UAV pod processor.

An unmanned aerial vehicle (UAV) storage and launch system also includes a UAV pod having a rotatable protective cover, a vertical takeoff and landing (VTOL) UAV enclosed in the UAV pod, and a UAV guide extending from the rotatable cover and engaging the UAV so that the VTOL UAV is protected from rain and particulate matter inside the UAV pod when the rotatable cover is in the closed position. The system may also include a rotatable landing surface, the rotatable landing surface co-rotatable complementary with the rotatable cover to position the UAV for takeoff when the rotatable cover is open. In one embodiment, the rotatable landing surface and rotatable protective cover are separately rotatable. In another embodiment, the rotatable landing surface and rotatable protective cover are rotatably engaged to co-rotate together. The UAV may be in a horizontal position when the rotatable protective cover is in the closed position, and in a vertical position when the rotatable protective cover is in the open position. The UAV guide may be a post. In embodiments, the rotatable cover may be coupled to the rotatable landing surface through an armature, the rotatable cover and rotatable landing surface rotatably engage to co-rotate together. The system may also include a UAV pod processor and a UAV pod transceiver in communication with the UAV pod processor. In such embodiments, the UAV pod processor may be configured to launch the UAV autonomously and without concurrent human intervention. The UAV pod processor may also be configured to receive geographic survey data and to save the geographic survey data in a UAV pod memory that is in communication with the UAV pod processor.

A method of unmanned aerial vehicle (UAV) pod control includes rotating a UAV pod protective cover from a closed position to an open position, rotating a landing surface from storage position to a launch position and transmitting a launch command from a UAV pod transmitter to a UAV transceiver to launch the UAV autonomously and without concurrent active human intervention in response to a preprogrammed condition. The rotating of the UAV pod protective cover and the rotating of the landing surface may occur concurrently. In an alternative embodiment, the rotating of the UAV pod protective cover happens before the rotating of the landing surface.

BRIEF DESCRIPTION OF THE DRAWINGS

The components in the figures are not necessarily to scale, emphasis instead being placed upon illustrating the principals of the invention. Like reference numerals designate corresponding parts throughout the different views. Embodiments are illustrated by way of example and not limitation in the figures of the accompanying drawings, in which:

FIG. **1** is a perspective view of one embodiment of a UAV pod that may house and protect an extended range VTOL UAV to accomplish multiple autonomous launches, landings and data retrieval missions;

FIG. **2** is a perspective view of the two-rotor UAV first illustrated in FIG. **1**;

FIGS. **3**A and **3**B illustrate the UAV pod in its open and closed configurations, respectively;

FIG. **4** is a flow diagram illustrating one embodiment of a method of conducting flight missions for the UAV;

FIGS. **5** and **6** are perspective views depicting closed and open embodiments, respectively, of a UAV pod that has a protective cover configured to rotate cooperatively with a rotatable landing surface to create a UAV pod having a low profile;

FIGS. **7** and **8** are side perspective and cross sectional views, respectively, of another embodiment of a UAV pod having a low profile when closed, with lateral faces angled for low wind resistance and favorable positioning of solar cells;

FIG. **9** depicts an open position of the UAV pod cover first illustrated in FIGS. **7** and **8**;

FIGS. **10**, **11**, **12** and **13** illustrate perspective views of closed, ready-for-landing, landed, and ready-for-closing configurations, respectively, of another embodiment of a UAV pod that allows for advantageous orientation for take-off and landing of a UAV in wind; and

FIG. **14** depicts a system including a portable UAV pod that can be relocated and positioned by the UAV carrying it from a position "A" to position "B".

DETAILED DESCRIPTION

A vertical takeoff and landing (VTOL) unmanned aerial vehicle (UAV) storage and launch system is disclosed that provides for improved remote geographic survey capabilities. Multiple autonomous mission launches and landings may be accomplished using a two-rotor VTOL UAV that is capable of efficient horizontal flight, and a UAV pod having a UAV pod processor, with the UAV selectively enclosed in the UAV pod for protection against the external environment when not in use, recharging and/or transferring data.

A UAV pod is described that may transition between an open position and a closed position. In the closed position, the UAV pod may be waterproof and protect a UAV enclosed inside the UAV pod from other particulate matter that may exist in the external environment. In the open position, the UAV pod may orient the UAV into a position for launch and/or landing. The UAV pod may have a two-part hinged cover that translates away from the UAV when moving from a closed position to an open position. In other embodiments, the UAV pod may have four lateral faces that form a cover or have a retractable cover. The cover may have solar panels on an external surface of the cover and these external surfaces may be moved to maximize solar energy collection during the time between the UAV launch and the UAV landing. The UAV pod may have a proximity sensor that detects any objects above the UAV pod before launching the UAV and/or transitioning to an open position.

Exemplary UAV Pod and UAV Structure

FIG. **1** is a perspective cut-away view of one embodiment of a UAV pod in a closed position that may house and protect an extended range VTOL UAV to accomplish multiple autonomous launches, landings and data retrieval missions. The illustrated system **100** has a winged two rotor UAV **102** seated on a landing surface **104** of an interior **106** of the UAV pod **108**. The UAV **102** is seated in a vertical launch position to facilitate later launch out of the UAV pod **108**. The UAV pod **108** may selectively enclose the UAV **102**, such as through the use of a UAV pod protective cover **110**. The cover **110** may be a two-part hinged cover that is operable to open to enable launch and landing of the UAV **102** and to position closed to establish an interior that weather resistant to an external environment that may include rain, snow, sleet, dust, and other particulate matter to protect the enclosed UAV **102**. Such hardening may be accomplished using pliable seals disposed about a perimeter of the cover or by the use of overlapping cover material or by other means. In other embodiments, the UAV pod **108** is waterproof when the cover **110** is closed. The UAV pod **108** may have a short-range UAV pod transceiver **112** that may be seated in a compartment below the landing surface **104**, within their own separate compartments, or may be seated elsewhere within the UAV pod **108** for protection from the external environment. The UAV pod transceiver **112** may receive UAV flight telemetry such as UAV flight and trajectory information, UAV battery status information and sensor data (such as video), and other data transmitted by the UAV **102**. The UAV pod transceiver **112** may also transmit flight control data such as navigation (e.g., re-routing instructions) to the UAV **102**. A UAV pod processor **114** may also be housed within the UAV pod **108** to accomplish, among other functions, providing the UAV **102** with a plurality of missions, receiving flight survey data from the UAV **102**, monitoring the UAV pod **108** for overhead obstacles, monitoring the external environment such as the weather through the weather sensor, monitoring the trajectory of the UAV **102**, and providing navigation instructions to the UAV **102** in response to receiving UAV battery status or other flight warning condition data inputs.

A UAV pod memory **116** may also be housed within the UAV pod **108** for storing UAV flight mission information and geographic survey data. A UAV pod battery **118** may be enclosed in the UAV pod for recharging the UAV **102** and for providing power to the UAV pod **108** such as for use by the processor **114** and cover motor (not shown). The battery **118** may be rechargeable such as through solar panels **119**, or may be a permanent battery such as a 12-Volt deep cycle marine battery. In an alternative embodiment, the battery **118** may be a fuel cell. In some embodiments, the UAV pod **108** will use the solar panels **119** to charge the battery **118** to later charge the battery of the UAV **102**. Typically, the UAV pod **108** will be charging the battery **118** while the UAV **102** is out of the pod **108** executing a mission and will recharge the UAV **102** upon its return to the UAV pod **108**.

A weather sensor **120** in communication with the UAV pod processor **114** may extend from an exterior of the UAV pod **108** to enable accurate measurement of the external environment, such as wind speed, temperature and barometric pressure. A proximity sensor or sensors may also be provided (**122**, **124**) and in communication with the UAV pod processor **114** to enable go and no-go flight decisions based on the proximity of any objects or other obstructions positioned over the UAV pod cover **110**. The remainder of the UAV pod **108** is also preferably weather hardened to enable extended outdoor use regardless of weather conditions such as rain, snow, sleet, dust, and other particulate matter.

FIG. **2** is a perspective view of the two-rotor UAV **102** first illustrated in FIG. **1**. The UAV **102** has only two rotors **202**, enabling vertical takeoff and landing (VTOL) missions out of the UAV pod **108** (see FIG. **1**). The UAV **102** has a UAV transceiver **204** within a UAV fuselage **206**. A UAV processor **208** is also seated in the UAV **102** and in communication with the UAV transceiver **204**. The UAV **102** also includes a battery **209** for providing power to the rotor motors and the electronics, including the processor **208**. The UAV processor **208** is configured to receive a plurality of flight mission information that may include waypoints, altitude, flight speed, sensor suite configuration data, launch day/time and mission weather sensor go and no-go parameters. The UAV **102** may have a variety of electrical optical (EO) sensors **210**, such as LiDAR, RADAR, infrared, visible-spectrum cameras, or other active or passive sensors that may be used to detect soil moisture, crop density, crop health, terrain, or other objects or qualities of interest. The UAV **102** may have a rear landing gear **212** extending off of a rear of the fuselage **206** that may be used in combination with UAV engine nacelles **214** to enable a four-point landing for more stable landings on the UAV pod **108** (see FIG. **1**). The landing gear **212** may also function as a flight surface or aerodynamic surface, such as a vertical stabilizer, providing corrective (passive) forces to stabilize the UAV **102** in flight, such as to stabilize in a yaw direction. The UAV **102** may have wings **215** to provide the primary source of lift during the UAV cruise (e.g., horizontal flight), while the two rotors **202** provide the primary source of lift during the VTOL phases of UAV flight. This combination of wing and rotor use allows for efficient flight while collecting flight survey data, which increases the range and/or duration of a particular flight while also allowing the UAV **102** to land and take off from the relatively small UAV pod **108** (see FIG. **1**) landing area. In one embodiment, the UAV **102** may take off and land vertically using the two rotors **202** that themselves are operable to lift the UAV **102** vertically upwards, transition the UAV **102** to horizontal flight to conduct its survey or other flight mission, and then transition it back to vertical flight to land the UAV **102** vertically downwards, with attitudinal control for the UAV **102** in all modes of flight (vertical and horizontal) coming entirely from the rotors **202** (as driven by a means of propulsion) without the benefit or need of aerodynamic control surfaces, such as ailerons, an elevator, or a rudder. One such UAV **102** is described in international patent application number PCT/US14/36863 filed May 5, 2014, entitled "Vertical Takeoff and Landing (VTOL) Air Vehicle" and is incorporated by reference in its entirety herein for all purposes. Such a UAV **102** benefits from a more robust structure by reducing the opportunity for damage to control surfaces (i.e., there aren't any), and may be made lighter and with less complexity.

The UAV **102** may also be provided with a rearward facing tang **216** extending off of a rear portion **218** of the fuselage **206** in lieu of or in addition to rear landing gear **212**. Such rearward-facing tang **216** may be metallic or have metallic contacts for receipt of electrical signals (i.e., data) and/or power for charging the UAV's battery **209**.

FIGS. **3**A and **3**B illustrate the UAV pod **108** in its open and closed configurations, respectively. In FIG. **3**A, the UAV **102** is illustrated in its vertical configuration and seated on a landing surface **104** of the UAV pod **108**. The UAV **102** is shown positioned at least generally aligned with the rectangular dimensions of the UAV pod **108**. In embodiments, the landing surface **104** is rotatable to position the UAV. In FIG. **3**A, the cover **110** is open to enable unobstructed launch, and later landing, of the UAV **102**. The cover **110** is illustrated with side portions **300** and top portions **302**, with hinges **304** that are operable to rotate the cover **110** away from the UAV for launch. In an alternative embodiment, only the top portions **302** are hinged to enable unobstructed launch of the UAV **102**. Alternatively, the top portions **302** may translate out of the flight path linearly or using a mechanism and motion so that the UAV is free to launch. In one embodiment, the landing gear **212** may be omitted and the UAV **102** may be guided into and out of one or more slots, guide rails, channels, or other guiding structure to both secure the UAV **102** during its landed state and enable landing. The weather sensor **120** may be coupled to the cover **110** or may extend off the side of the UAV pod **108** (not shown). Also, although the UAV pod **108** is illustrated having a rectangular cross-section and a box-like structure, the UAV pod **108** may take the form of a dome-shaped structure or other configuration that enables stable placement and protection for the selectively enclosed UAV. The cover **110** can include solar panels on its exterior (not shown), and in some embodiments one or both of the covers **110** can be positioned, and moved, about the hinges **304** to be perpendicular to the sun's rays to maximize the collection of solar energy. In other embodiments, the short-range UAV pod transceiver **112** may also have features of or include a long-range UAV pod transceiver **113** for communication with a cellular tower.

Local UAV Operation

FIG. **4** is a flow diagram illustrating one embodiment of a method of conducting flight missions for the UAV. The UAV may be provided with one of the plurality of missions (block **400**) that reside in the UAV pod. The UAV may be caused to launch vertically out of the UAV pod (block **402**) in response to a comment from a UAV pod processor, preferably under the UAV's own power using the two rotors on the UAV. In one embodiment, the launch is commanded autonomously and without concurrent active human intervention in response to a pre-programmed condition such as day and time. The immediate environment over the UAV pod may be monitored for obstacles and weather (block **404**) that may otherwise interfere with launch of the UAV. In such an embodiment, if no obstructions are detected (block **406**), then the UAV may be launched out of the UAV pod (block **402**). Otherwise, launch of the UAV is delayed or cancelled and the UAV pod continues to monitor for overhead obstacles and weather (block **404**, **406**), as well as the UAV battery status (block **410**). After launch, the UAV pod may monitor the UAV's trajectory (block **408**). If UAV battery power is low or otherwise drops below a predetermined voltage threshold (block **412**), then the UAV pod may provide rerouting instructions to the UAV (block **414**) to shorten the current mission to enable a safe return of the UAV to the UAV pod. In an alternative embodiment, the UAV is directed to return immediately to the UAV pod (block **416**) or to an intermediate pre-determined position. If, however, the battery is not low (block **412**), and no other flight warning condition is triggered (block **418**) the mission continues (block **420**). If the current UAV mission has been completed (block **420**), the UAV returns to the UAV pod (block **416**) for landing and the geographic survey data is downloaded to the UAV pod memory (block **422**) such as by a wireless or wired transfer of the mission data to the UAV pod memory. The UAV pod protective cover may be closed (block **424**) to protect the UAV from the external environment (i.e., rain, direct sun, vandals, or damaging particulate matter).

Alternative UAV Pod Covers and Landing Mechanisms

FIGS. **5** and **6** are perspective views depicting closed and open embodiments, respectively, of a UAV pod that has a protective cover configured to rotate cooperatively with a rotatable landing surface to create a UAV pod having a low profile. The illustrated system **500** has a two rotor UAV **502** seated on a landing surface **504** of an interior **506** of the UAV pod **508**. The UAV pod **508** may selectively enclose the UAV **502**, such as through the use of a UAV pod rotatable protective cover **510**. A UAV guide **512** may extend from the rotatable protective cover **510** to engage the UAV **502** so that the UAV **502** is positioned and secured between the UAV guide **512** and the landing surface **504**. In one embodiment, the UAV guide **512** is a post that abuts or otherwise presses against an exterior surface of the UAV **502** to hold it to the landing surface **504** using friction. In another embodiment, the UAV guide **512** is a mechanism that engages with the UAV **502**, such as a clasp or ring that captures a complementary post or structure on the UAV **502** itself. The rotatable protective cover **510** may rotate about a hinge **514** to an open position (position "A"), with the landing surface **504** also operable to rotate about the hinge **514** from a storage position until the UAV **502** is rotatably positioned into a vertical launch position. The rotatable cover **510** is preferably rotatably engaged and coupled to the landing surface **504** through an armature **516** for co-rotation of each by a cover driver (not shown), although in an alternative embodiment the cover **510** and landing surface **504** are separately rotatable. In FIG. **6**, the UAV **502** is illustrated in its vertical configuration and supported by a support member (not shown). As the cover **510** rotates back to a closed position (position "B"), the landing surface also rotates to cooperatively rotate the UAV **502** back into the interior **506** of the UAV pod **508** to a storage position.

FIGS. **7** and **8** are side perspective and cross sectional views, respectively, of another embodiment of a UAV pod having a low profile when closed, with lateral faces angled for low wind resistance and favorable positioning of solar cells. The UAV pod **700** may have a quadrilateral base **702**, preferably rectangular, and polygonal lateral faces **704** that taper to a top of the UAV pod **700**. The solar cells **705** may be positioned on one or more of the polygonal lateral faces **704**. The polygonal lateral faces **704** may form a UAV pod cover **706** that may selectively enclose a two-rotor UAV in an interior **800** of the UAV pod **700**. The UAV pod cover **706** may be waterproof, but not sealed, for environmental protection for the UAV against the external environment. A battery **812** and UAV pod electronics **814** may be enclosed within an interior compartment **815** for further protection from the external environment. Cover UAV-support pads (**816**, **818**) extend from opposing lateral faces **704** of the UAV pod cover **706** into the interior **800** of the UAV pod **700** to abut and hold into position the UAV **802** when in the closed position (see FIG. **8**). This holding of the UAV **802** in place by the cover UAV-support pads **816** and **818** facilitate transportation of the UAV and pod system to and from locations by preventing or reducing possible damage to the UAV during transit.

FIG. **9** depicts an open position of the UAV pod cover **706** first illustrated in FIGS. **7** and **8**. In the illustrated embodiment, each of the four lateral faces **704** have respective hinges **900** that enable the faces **704** to rotate outwardly away from the interior **800** of the UAV pod **700** to expose the UAV **802** for unobstructed launch. The cover pads (**816**, **818**) may have UAV-facing surfaces **902** that have a complementary shape to that of an exterior surface **804** (see FIG. **8**) of the UAV to better secure the UAV from lateral movement within the interior. The cover pads (**816**, **818**) may also incorporate UAV charging and cooling functions so that as the cover **706** is closed to about the UAV **802**, the UAV pads (**816**, **818**) contact complementary contacts on the UAV (not shown) to close an electrical circuit for charging of the UAV's internal batteries, or to enable inductive charging (i.e., wireless charging) of the UAV's batteries. Such contacts may also enable closed-circuit communication between the UAV **802** and the UAV pod **700** (including the electronics **814**).

FIGS. **10**, **11**, **12** and **13** illustrate perspective views of closed, ready-for-landing, landed, and ready-for-closing configurations, respectively, of another embodiment of a UAV pod **1000** that allows for advantageous orientation for take-off and landing of a UAV in wind. An articulated roller top cover **1002** is operable to translate laterally across a top opening **1104** of the UAV pod **1000** to be taken up at a proximal end **1006** of the UAV pod **1000** (such as by rolling) to expose an interior volume **1100** of the UAV pod **1000**. A telescoping landing surface **1102** may translate up toward the top opening **1104** of the interior volume **1100** for receipt (or launch) of a UAV **1200**. Subsequent to the UAV **1200** landing on the landing surface **1102**, the landing surface **1102** may be rotated (indicated by arrows) to better position the UAV **1200** for receipt into the interior volume **1100**. For example, the UAV **1200** and associated wings **1202** may be rotated with the landing surface **1102** so that the wings **1202** do not impinge on side walls **1204** of the UAV pod **1000** (see FIG. **13**) as the UAV **1200** and landing surface **1102** are translated down into the interior volume **1100** for protective storage. Similarly, in preparation for takeoff, the UAV **1200** may be oriented to account for crosswind during launch.

Methods of Agricultural Survey Use—Non-Contiguous Areas ("UAV Migration")

As shown in FIG. **14**, in embodiments, the system may include a portable UAV pod **1400** that can be relocated and positioned by the UAV **1402** carrying it. The UAV pod **1400** is generally lighter and smaller than other UAV pods set forth herein so as to allow it to be carried by the UAV **1402**. The weight and size of the pod **1400** could be reduced by any of a variety of means including having it lack doors to enclose the UAV **1402**. Such a pod **1400** could be used as a way station for the UAV **1402** to stop at to recharge and extend its overall range. Also, by having the UAV pod **1400** being able to be positioned by the UAV **1402** would allow the pod **1400** to be placed in otherwise effectively inaccessible locations, such as on top of a mountain or on an island.

As shown in FIG. **14**, the UAV **1402** starts on the pod **1400** in location A, where the UAV **1402** is physically attached to the pod **1400**. Then the UAV **1402** takes off vertically with the pod **1400** to deliver it to a remote location B, at which the UAV **1402** can detach from the pod **1400** and leave it in place. To aid in its transport the UAV pod **1400** may have portions **1404** and **1406** that can fold up during transport and unfold prior to landing at the new location. The folding portions **1404** and **1406** could be solar panels to collect and power the pod **1400** and the UAV **1402**. Positioning pods **1400** in this manner would allow for a tailoring of the geographic area that the UAV could cover. Such lighter less capable pods **1400** could work in conjunction with more functional fix position pods, such as those set forth herein as the pods **1400** would provide less functions (e.g., charging only) than the fixed pods (e.g., charging, data processing, data transmission, an enclosure for UAV protection, etc.).

In summary of the system disclosed herein, a VTOL UAV storage and launch system may include a UAV pod having a UAV pod processor, and a UAV selectively enclosed in the UAV pod, the UAV having only two rotors. The system may include a display on the UAV pod and/or a rearward facing tang extending from a rear fuselage portion of the UAV.

Another unmanned aerial vehicle (UAV) storage and launch system is disclosed that includes a UAV pod having a UAV pod processor and short-range UAV pod transceiver, a vertical takeoff and landing (VTOL) two-rotor UAV enclosed in the UAV pod, the two-rotor UAV having a UAV processor and a UAV transceiver, the UAV processor in communication with the UAV pod processor through the short-range UAV pod transceiver and the UAV transceiver. The UAV pod processor may be configured to provide mission instructions to the UAV processor and to monitor UAV trajectory information. The system may also include a proximity sensor coupled to the UAV pod, with the proximity sensor configured to detect the presence of an object positioned over the UAV pod, when an object is present. A weather sensor may also be included that is in communication with the UAV pod processor, and a UAV pod memory may be in communication with the UAV pod processor. In some configurations, the UAV pod memory is portable memory, such as a secure digital (SD) card, and the system may include a long-range UAV pod transceiver coupled to the UAV pod and in communication with the UAV pod processor, with the UAV pod processor further configured to monitor UAV pod external environmental conditions in response to information received from the weather sensor. The UAV pod processor may be further configured to provide reroute instructions to the two-rotor UAV, and the rerouting instructions may include instructions to return to the UAV pod for landing. In preferred embodiments a UAV pod cover is included that is operable to open and close.

A method of unmanned aerial vehicle (UAV) launch and control is also described that includes transmitting one of a plurality of missions to a two-rotor UAV seated in a UAV pod, launching the two-rotor UAV out of the UAV pod, monitoring a trajectory of the two-rotor UAV using a UAV pod transceiver in communication with a UAV pod processor, the UAV pod processor coupled to the UAV pod, and monitoring a battery status of the two-rotor UAV during flight. The method may also include providing re-routing instructions to the two-rotor UAV from the UAV pod and the re-routing instructions may include UAV instructions to return to the UAV pod for landing. In certain embodiments, the method may also include downloading geographic survey data from the two-rotor UAV to a UAV pod memory in communication with the UAV processor, and the UAV pod memory may be portable memory detachably connected to the UAV pod. In other embodiments, the method may include landing the two-rotor UAVs in the UAV pod, closing a UAV pod protective cover over the two-rotor UAV, downloading geographic survey data from the two-rotor UAV to a UAV pod memory in communication with the UAV processor, transmitting another one of a plurality of missions to the two-rotor UAV seated in the UAV pod, opening the protective cover, and launching the two-rotor UAV out of the UAV pod. The launch and control method may also include monitoring for overhead obstacles using a proximity sensor, monitoring the weather using a weather sensor, and transmitting the geographic survey data to an operations center disposed remote from the UAV pod.

Another unmanned aerial vehicle (UAV) storage and launch system is described that includes a UAV pod processor, and a UAV pod transceiver in communication with the UAV pod processor, the UAV pod processor configured to monitor a predetermined two-rotor UAV, when the two-rotor UAV is present, a two-rotor UAV trajectory, and a UAV battery status; and a UAV pod memory in communication with the UAV pod processor, the UAV pod memory storing a plurality of UAV missions that collectively provide a geographic survey of an area.

While various embodiments of the invention have been described, it will be apparent to those of ordinary skill in the art that many more embodiments and implementations are possible that are within the scope of this invention.

What is claimed is:

1. A method of migrating unmanned aerial vehicle (UAV) operations between geographic survey areas, comprising:

launching, by a UAV from a first location, the UAV having a portable UAV pod, wherein the portable UAV pod is attached to the UAV at launch;

flying, by the UAV, the UAV having the portable UAV pod to a second location;

landing, by the UAV, the UAV having the portable UAV pod at the second location;

detaching the UAV from the portable UAV pod; and

launching the UAV from the portable UAV pod at the second location.

2. The method of migrating UAV operations between geographic survey areas of claim **1** wherein the portable UAV pod folds up during flight of the UAV and unfolds prior to landing.

3. The method of migrating UAV operations between geographic survey areas of claim **1** wherein the portable UAV pod does not have doors to enclose the UAV.

4. The method of migrating UAV operations between geographic survey areas of claim **1** further comprising:

charging the UAV by the portable UAV pod.

5. The method of migrating UAV operations between geographic survey areas of claim **1** wherein landing the UAV having the portable UAV pod at the second location further comprises:

positioning, by the UAV, the portable UAV pod at the second location.

6. The method of migrating UAV operations between geographic survey areas of claim **1** wherein the second location is on an island.

7. The method of migrating UAV operations between geographic survey areas of claim **1** wherein the second location is on top of a mountain.

8. The method of migrating UAV operations between geographic survey areas of claim **1** wherein the second location is an otherwise effectively inaccessible location.

9. The method of migrating UAV operations between geographic survey areas of claim **1** wherein the portable UAV pod is physically attached to the UAV at launch.

10. The method of migrating UAV operations between geographic survey areas of claim **1** wherein launching the UAV comprises a vertical takeoff of the UAV.

11. The method of migrating UAV operations between geographic survey areas of claim **1** wherein the UAV is a vertical takeoff and landing (VTOL) UAV.

12. The method of migrating UAV operations between geographic survey areas of claim **1** wherein the portable UAV pod comprises one or more folding portions.

13. The method of migrating UAV operations between geographic survey areas of claim **12** wherein the one or more folding portions comprise solar panels.

14. The method of migrating UAV operations between geographic survey areas of claim **13** further comprising:

charging, by the solar panels, a UAV pod battery.

15. The method of migrating UAV operations between geographic survey areas of claim **12** further comprising:

folding up the one or more folding portions during flight of the UAV.

16. The method of migrating UAV operations between geographic survey areas of claim 12 further comprising: unfolding the one or more folding portions prior to landing of the UAV.

17. The method of migrating UAV operations between geographic survey areas of claim 14 further comprising: charging, by the UAV pod battery, the UAV.

18. The method of migrating UAV operations between geographic survey areas of claim 1 further comprising: landing, by the UAV, the UAV at a fixed UAV pod at a third location.

19. The method of migrating UAV operations between geographic survey areas of claim 18 further comprising: enclosing, by the fixed UAV pod, the UAV within the fixed UAV pod.

20. The method of migrating UAV operations between geographic survey areas of claim 18 further comprising: transmitting data between the fixed UAV pod and the UAV.

21. The method of migrating UAV operations between geographic survey areas of claim 18 further comprising: charging the UAV by the fixed UAV pod.

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